Design of a Nanophotonic Hybrid Coupler
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Problem of Interest

- LA scintillation light: 128 nm [1]
- LXe scintillation light: 175 nm [1]
- Current VUV photodetectors have low efficiencies [1, 2]
- Wavelength shifters down covert VUV light to a longer wavelength [1]
- Light needs to be focused and enhanced to allow better detection [3]
- Metalens: nanostructured surfaces used to manipulate light [4]
- Purpose: design a hybrid (plasmonic-dielectric) coupler that has wavelength shifting properties and can achieve partial far-field radiation control and high Purcell enhancement

Solution

- A cylindrical cSi resonator for field confinement
- A ZnO layer as an intrinsic wavelength shifter (excited by VUV light and emit at ~390 nm) [5]
- A Z-oriented electric dipole source with an offset of 27.2 nm
- Ag and SiO₂ substrate
- Advantages of plasmonics: high local fields and Purcell enhancement [3]
- Advantages of dielectrics: low absorption loss [3]

Methods

- Finite-difference time domain (FDTD) method for Maxwell’s equations
- MEEP: an open-source package scriptable in Python, Scheme, C++ [6]
- Lumerical: a commercial photonic simulation software [7]

Results and Conclusions

- Purcell factor reaches a maximum (~10⁴) near 390 nm (Figure 3)
- Enhancement of spontaneous emission rate due to environment [8]
- Ratio of power emitted in a specific environment to power emitted in a homogenous environment [8]
- Partial control of the far-field radiation (Figure 4)
- Without the resonator: radiation going sideways
- With the resonator: radiation directed towards the coupled metalens
- Future: further optimization of the coupler, design of the metalens

Acknowledgements

- This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics.
- This work was supported in part by the U.S. Department of Energy, Office of Science, Office of Workforce Development for Teachers and Scientists (WDTS) under the Science Undergraduate Laboratory Internships Program (SULI).

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